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Geographic information — Functional standards

Information géographique — Normes fonctionnelles

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this Technical Report may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 19120 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

Introduction

The ISO 19100 series of geographic information standards under development within ISO/TC 211 provides a framework for the development of geographic information standards. There are a number of existing functional standards in use within the international community that would seek to achieve compliance with the emerging ISO 19100 series of standards.

The availability of a common frame of reference, as provided by the ISO 19100 series, may also present an opportunity for harmonization between the functional standards to the extent that such harmonization supports the primary goal of harmonization of the functional standards with the ISO 19100 series, but harmonization between functional standards is not the subject of this report. This Technical Report seeks to identify how functional standards can be developed as profiles of the ISO 19100 series of standards and how this profiling process can promote harmonization between these functional standards.

Geographic information — Functional standards

1 Scope

Within the context of this Technical Report, a functional standard has been identified as an existing geographic information standard, in active use within the international community. National standards have not been considered within this report.

This Technical Report seeks to identify the components of those recognized functional standards and to identify elements that can be harmonized between these standards and with the ISO/TC 211 base standards. This Technical Report provides a starting point for a feedback cycle between the functional standards communities and the ISO 19100 series component project teams.

2 References

ISO/IEC 8211:1994, *Information technology — Specification for a data descriptive file for information interchange*

ISO/IEC 8824 (all parts):1998, *Information technology — Abstract Syntax Notation One (ASN.1)*

ISO/IEC TR 10000-1:1998, *Information technology — Framework and taxonomy of International Standardized Profiles — Part 1: General principles and documentation framework*

ISO 19101:—[1)], *Geographic information — Reference model*

ISO 19102:—[1)], *Geographic information — Overview*

ISO/TS 19103:—[1)], *Geographic information — Conceptual schema language*

ISO 19104:—[1)], *Geographic information — Terminology*

ISO 19105:2000, *Geographic information — Conformance and testing*

ISO 19106:—[1)], *Geographic information — Profiles*

ISO 19107:—[1)], *Geographic information — Spatial schema*

ISO 19108:—[1)], *Geographic information — Temporal schema*

ISO 19109:—[1)], *Geographic information — Rules for application schema*

ISO 19110:—[1)], *Geographic information — Feature cataloguing methodology*

ISO 19111:—[1)], *Geographic information — Spatial referencing by coordinates*

ISO 19112:—[1)], *Geographic information — Spatial referencing by geographic identiers*

ISO 19113:—[1)], *Geographic information — Quality principles*

ISO 19114:—[1)], *Geographic information — Quality evaluation procedures*

1) To be published.

ISO 19115:—[1)], *Geographic information — Metadata*

ISO 19116:—[1)], *Geographic information — Positioning services*

ISO 19117:—[1)], *Geographic information — Portrayal*

ISO 19118:—[1)], *Geographic information —Encoding*

ISO 19119:—[1)], *Geographic information —Services*

ISO/TR 14825, *Geographic Data Files (GDF)*

CEN ENV 14825, *Geographic Data Files (GDF)*

Digital Geographic Exchange Standard (DIGEST). Digital Geographic Information Working Group — Edition 2.0 June 1997

International Hydrographic Organization (IHO) Transfer Standard S-57, Edition 3.0

3 Terms and definitions

For the purposes of this Technical Report, the following terms and definitions apply.

3.1
encapsulation
collection of specified data content in a well-defined coding structure or the process by which it is done

3.2
functional standard
existing geographic information exchange standard, developed specifically for transfer of data between entities in different nations, and currently used for that purpose

3.3
module
predefined set of elements in a base standard that may be used to construct a profile

3.4
profile
set of one or more base standards and - where applicable - the identification of chosen clauses, classes, subsets, options and parameters of those base standards that are necessary for accomplishing a particular function

[ISO/IEC TR 10000-1:1998]

3.5
product specification
description of the universe of discourse and a specification for mapping the universe of discourse to a dataset

4 Abbreviated terms

BIIF	Binary Image Intechange Format
CHRIS	Committee on Hydrographic Requirements for Information Systems (IHO)
CHS	Canadian Hydrographic Service
DBWG	Data Base Working Group, now called TSMADWG (IHO)

DIGEST	Standard for the exchange of digital geographic information. Supports the exchange of DGI required to support military operations
DGI	Digital geographic information
DGIWG	Digital Geographic Information Working Group
DNC	Digital Nautical Chart (DIGEST)
ECDIS	Electronic Chart Display Information System (S-57)
ENC	Electronic Nautical Chart (S-57)
FACC	Feature and Attribute Coding Catalogue (DIGEST)
FRS	Feature Representation Scheme (GDF)
GDF	Geographic Data Files (CEN/ISO), standard for definition and exchange of digital road databases with a focus on navigation applications
HO	Hydrographic Office
HWP	Harmonization Working Party (joint DGIWG/IHO)
ICD	Interface Control Document (DGIWG/IHO HWP)
IHB	International Hydrographic Bureau (secretariat of the IHO)
IHO	International Hydrographic Organization
IIF	Image Interchange Format
IMO	International Maritime Organization
MD	Maintenance Document (refers to S-57, published by TSMADWG)
NATO	North Atlantic Treaty Organization
OGC	Open GIS Consortium, Inc.
OGIS	Open GIS
S-57	IHO Transfer Standard; standard for the exchange of digital hydrographic data between national Hydrographic Offices, and for the distribution of such data to manufacturers, mariners and other users
STANAG	Standardization Agreement (NATO)
TSMAD	Transfer Standard Maintenance and Applications Development Working Group (IHO)
USOC	Use of the Object Catalogue for ENC (S-57)
VRF	Vector Relational Format (DIGEST encapsulation)

5 Review of functional standards

5.1 General

This Technical Report reviews a selection of functional standards currently in use within the international digital geographic information community. The standards selected are not intended to represent an exhaustive review of all the de-facto international geographic data standards currently in existence. Such work has been carried out by other organizations; rather than duplicating their effort, this Technical Report addresses a number of existing standards in wide use at the current time.

The experience gained in considering the activities required to develop these functional standards into profiles of the ISO 19100 series of standards is valuable to any developer or data producer considering the use of profiles as a mechanism for achieving compliance with the ISO 19100 series.

The review of the functional standards in parallel with the development of the ISO 19100 series of standards, has identified the need for liaison between the International Standard developers and the functional standard community.

— The “sequential” development of International Standards should be cyclically linked to the external functional standards communities. This provides for a “sanity check” on the emerging international standards by providing real test cases.

— Once the component base standards have reached International Standard status, they still may not be adequate to handle all requirements of the functional standards. These outstanding requirements may prompt future versions of the standard to be developed.

Three functional standards are considered within this Technical Report. They are as follows.

— DIGEST (Digital Geographic Exchange Standard): In use to support the military DGI requirements amongst NATO nations. The standard is maintained by the Digital Geographic Working Group (DGIWG).

— GDF (Geographic Data Files): In use to define and exchange digital road databases, with a particular emphasis on navigation applications.

— S-57: In use to support the exchange of digital hydrographic data between national Hydrographic Offices and for distribution to manufacturers, mariners, and other data users.

Each of the functional standards considered within this Technical Report comes from a different user community, and as such brings a unique perspective to the profiling activity. Each of the standards and their intended audience are summarized in the following sections.

5.2 The Digital Geographic Information Working Group (DGIWG) DIGEST Standard

5.2.1 Introduction

The Digital Geographic Information Working Group (DGIWG) was established in 1983 to support the exchange of Digital Geographic Information (DGI) among the military of NATO nations. The DGIWG membership includes Belgium, Canada, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, the UK and the US. Four countries have observer status: Australia, Portugal, Greece and New Zealand.

The DGIWG is not an official NATO body; however, the DGIWG's standardization work has been recognized and welcomed by the NATO Geographic Conference (NGC). The DGIWG developed and maintains DIGEST as an exchange standard to facilitate the exchange of DGI to support interoperability within and between the military components of NATO nations, and to promote burden sharing of digital data production. The scope of this activity includes dataset specification development and harmonization of standards.

The DIGEST standard has been subject to continual evolution, in order to satisfy the requirements of the defence user community, and has evolved beyond its initial conception as an exchange standard, and now forms a true geospatial standard, addressing quality, data modelling and feature cataloguing in addition to data exchange formats.

In the future, defence data providers will be required to support multinational forces with global coverage of geographic data. This data will need to be produced accurately and provided quickly in order to support the needs of the forces. Thus the need to burden share and to interoperate is critical. The DGIWG seeks to meet this objective by developing DIGEST in order to provide a common core of data standards and processes to support interoperability.

DIGEST has become a NATO standardization agreement (STANAG 7074) and the latest version of DIGEST, edition 2.0, was released in June 1997.

5.2.2 Contents

DIGEST supports the exchange of raster, matrix, imagery and vector DGI (and associated text) among producers and users. DIGEST supports a range of vector topological structures:

— Level 0 topology - “Spaghetti”

— Level 1 topology - “Chain-Node”

— Level 2 topology - “Planar Graph”

— Level 3 topology - “Planar Graph with Face”

The standard describes a variety of encapsulations, which are in effect profiles, for the various data models supported by DIGEST. These encapsulations are defined in a series of Annexes to the standard. DIGEST also includes the Feature and Attribute Coding Catalogue (FACC), which forms a comprehensive coding scheme for features, their attributes and attribute values.

The structure of the DIGEST document is as follows:

a) Part 1: General Description

b) Part 2: Theoretical Model, Exchange Structure and Encapsulation Specifications

   — Annex A: ISO/IEC 8211 Encapsulation Specifications

   — Annex B: ISO/IEC 8824 Encapsulation Specifications

   — Annex C: Vector Relational Format (VRF) Encapsulation Specification

     DIGEST VRF encapsulation describes the vector format supported by the DIGEST standard. VRF supports multiple levels of vector topology, and also supports application level relationships between features, such as “connected to”, “stacked on” and “stacked under”.

   — Annex D: Image Interchange Format (IIF) Encapsulation

     IIF complies with the Binary Image Interchange Format (BIIF).

   — Annex E: ASCII Encapsulation

     Table of contents when the transmittal is non-standard (due to more than one kind of data structure or encapsulation)

c) Part 3: Codes and Parameters

d) Part 4: Feature and Attribute Coding Catalogue.

   FACC is a data dictionary of feature and attribute definitions and coding schemes used across the DIGEST family of products.

A number of products have been developed to the DIGEST standard, and are in active use. These include:

ASRP ARC standard raster product

DTED Digital Terrain Elevation Data

DNC Digital Nautical Chart

VMAP Vector map - A family of vector mapping products derived from high, medium and low scale sources

WVS World Vector Shoreline

Further information is available from the DIGEST web site http://www.digest.org

5.2.3 Maintenance

DIGEST is maintained by the DGIWG. A number of working parties have been set up to address technical issues associated with the standard. These working parties are directed by, and report to the DGIWG Technical Committee, which in turn reports to the DGIWG Steering Committee.

The working parties address issues arising from the current edition of DIGEST, and also seek to develop DIGEST to meet the emerging requirements of the DGIWG user community.

Currently the DGIWG is planning development of DIGEST edition 3.0. Edition 3.0 will be developed making use of the ISO 19100 series of standards.

5.3 The International Hydrographic Organization (IHO) S-57 Transfer Standard

5.3.1 Introduction

The International Hydrographic Bureau (IHB) in Monaco (founded in 1926), is the Secretariat of the International Hydrographic Organization (IHO). The IHO is an international organization based upon an intergovernmental convention that came into force in 1970. IHO presently comprises 67 Member States represented by their Hydrographic Offices (HOs). Additionally, application for IHO membership by approximately 10 states is pending. Most of the major coastal states are members of the IHO.

The IHO Transfer Standard S-57 is intended to be used for the exchange of digital hydrographic data between national Hydrographic Offices and for distribution to manufacturers, mariners, and other data users. S-57 was adopted as the official IHO standard by the XIVth International Hydrographic Conference, Monaco, 4-15 May 1992. It supports the exchange of vector (and later raster and matrix) hydrographic data. It comprises a theoretical data model, on which the standard has been based, a description of the data structure, and a catalogue of objects and attributes. In the data structure, provision has been made for the encoding of chart updates.

Additionally, S-57 includes a product specification for Electronic Nautical Chart (ENC). Edition 3.0 of S-57 was published in November 1996, and use of S-57 is specified in the IMO Performance Standards for ECDIS (IMO Resolution A/817 (19), December 1995).

S-57 has been frozen for four years, from November 1996, with a view to allowing HOs to produce ENC data conforming to Edition 3.0, and ECDIS manufacturers to market their systems.

It is currently available in both digital and paper formats. The printed version includes only a selection of the pages from the Object Catalogue.

5.3.2 Contents

The ISO Transfer Standard S-57 has the following contents.

— Part 1: General Introduction

— Part 2: Theoretical Data Model

— Part 3: Data Structure

  — Annex A: ISO/IEC Summary & Examples

  — Annex B: Alternate Character Sets

- Appendix A: IHO Object Catalogue
  - Chapter 1: Object Classes
  - Chapter 2: Attributes
  - Annex A: IHO Codes for Producing Agencies
  - Annex B: Attributes/Object Classes Cross-reference
- Appendix B: Product Specifications
  - Appendix B1: ENC Product Specification
  - Annex A: Use of the Object Catalogue for ENC
  - Annex B: CRC Code
- Appendix B2: Data Dictionary Product Specification

5.3.3 Maintenance

The IHO Transfer Standard, S-57 Edition 3.0, is maintained by means of “Maintenance Documents” (MD). These MDs are produced by the IHO TSMAD, through an agreed maintenance mechanism.

Each MD contains three sections: Clarifications, Corrections and Extensions. Each of these is explained in its respective Introduction section. Each time that the Transfer Standard Maintenance and Applications Development Working Group (TSMAD) meets and produces any changes, clarifications or extensions to the Standard, a new MD is produced.

Within a Maintenance Document, each item is assigned a unique Identifier. This Identifier takes the following form:

MD.SS.NNN

where MD = the MD Number, SS = the Section Title (Cl: Clarifications, Co: Correction, Ex: Extension), and NNN = the Item's sequential number within a section. For example, 1.Co.12 is the 12th item in the Corrections Section for MD 1. All items within a section are presented in the same order as the sections of the Standard.

MDs are made available from the IHO Website http://www.iho.shom.fr

S-57 MD No. 1 and S-57 MD No. 2 were released in November 1997 and June 1998 respectively.

In addition, Annex A to S-57 Appendix B1 “Use of the Object Catalogue for ENC” (USOC) is maintained by means of new editions, as this document may be subject to frequent changes. These new editions are also produced by the IHO TSMAD. Edition 1.2 of the USOC was released in June 1998 and it has been posted on the IHO Website.

5.4 The GDF standard

5.4.1 Introduction

GDF (Geographic Data Files) is a standard for the definition and exchange of digital road databases with a focus on navigation applications. Often GDF is seen as just an exchange standard, but it is more than that. It provides, in the first place a common framework for the production of digital road map databases for in-vehicle navigation systems and other applications.

GDF development started in 1984 in the Demeter project, was continued in several other European projects, and was taken up by CEN/TC 278 (Road Transport and Traffic Telematics - RTTT) in 1994. GDF reached a status of provisional completion in the document of 12 October 1995, describing GDF version 3.0, which was adopted by the CEN/TC 278 Plenary as an ENV (European pre-standard) in 1996. The completion is provisional, because in 1995 ISO/TC 204 started to contribute to GDF development in order to create a global GDF. In 1996 ISO adopted the CEN document as the primary input to this process. This work is expected to be completed in early 1999.

The reason for the creation of a standard like GDF is to enable road network related geographic information to be shared between different users, applications, systems and locations. In short: interoperability.

5.4.2 Contents

GDF is both a reference framework for data production and an exchange standard. As a reference framework it describes rules for modelling (representing) the real world in a road map database, to be used for a certain range of applications. Application developers can specify their requirements in terms of this reference framework, as can data producers define their product specification. For developers of new technology related to digital road data, the standard provides a useful guide to their work. In addition, the exchange standard facilitates the exchange of information defined according to the reference framework. Standardization in this way enhances the market, ensures compatibility between applications, now and in the future, and as such fosters interoperability.

The current pre-standard consists of the following components.

— **General data model**

This general, non-application-specific data model is the basic foundation of the standard, which ensures compatibility with other non-road-related data sources. It describes in a general way how real world features (and attributes and relationships) shall be modelled. It is described in chapter 4 of the GDF document.

In the GDF data model 3 levels are distinguished. At level 0, the world is modelled in terms of the geometric primitives node (isolated and non-isolated), edge, and face. If a non-planar representation is used, this level in fact already carries some of the topological information as well. At level 1, simple features are defined based on the modelled geometry. At level 2, complex features are defined based on simple features defined at level 1. Attributes and relationships point both to features at level 1 and to complex features at level 2. The major part of the topology is defined at levels 1 and 2.

— **Feature, attribute and relationship catalogues**

GDF has 3 catalogues, for features (chapter 5), attributes (chapter 6) and relationships (chapter 7). These catalogues, built on top of the general data model, together constitute a road network specific application model. They define road network related feature types, attributes types and relationship types, and describe more in detail how these can be modelled.

— **Feature representation scheme**

Although related to the road network, the catalogues are still valid for a wide range of applications. The Feature Representation Scheme (FRS; chapter 8) gives further modelling rules for a more restricted group of applications. The most important function of the FRS is that it defines to which feature category or categories a particular feature class must or may belong. In GDF four different feature categories (not the same as feature types) are used: point, line, area and complex features. The FRS defines e.g. that a road element shall always be represented (modelled) as a line feature. It would be possible to specify, in the framework of GDF, another FRS (for a different set of applications), that e.g. defines that a road element should always be represented as an area feature.

— **Quality description and metadata**

Chapter 9 (Quality description specifications) describes how quality should be measured and described. Chapter 10 (Global data catalogue) describes how the metadata of a GDF data set should be organized, to make it as self descriptive as possible.

— **The exchange format**

The exchange format, which is based on the information in the previous chapters, is defined in chapter 11 (GDF logical data structures) and chapter 12 (Media record specifications). The logical data structures define the data types to be used for the representation of the items that have been defined in the conceptual models of the previous chapters. The media record specifications describe the actual exchange format in a more restricted sense (i.e. the record layout).

GDF is designed for modelling road databases of a certain type, as most narrowly defined in the feature representation scheme. However, it should be appreciated that GDF can still accommodate databases that can differ considerably in data specification:

— resolution

— representation

— quality (accuracy, completeness, connectivity)

— set of feature types

— set of attribute types

— set of relationship types

Although at present a European pre-standard, GDF is increasingly being used in other parts of the world.

5.4.3 Maintenance

In 1999, GDF was being processed as an International Standard by ISO/TC 204.

6 Use of profiles to map functional standards to ISO 19100 base standards

6.1 Scope

It is the intent of ISO 19106 to define a profiling mechanism which will allow the definition of a mapping from any geographic information standard to the ISO 19100 series base standards. The geographic information standards so mapped might include functional standards, de jure standards, de facto standards, and proposed standards. If the objectives of ISO 19106 are achieved, profiles could become the mechanism whereby existing functional standards and newly developed standards are able to demonstrate compliance with the ISO 19100 series. A profile does not need address the entire spectrum of base standards covered by the ISO 19100 series, indeed some of the ISO 19100 series base standards may not be applicable to all functional standard.

A profile must describe how the functional standard implementation meets the mandatory requirements laid out in ISO 19100 series. These requirements must be addressed in order for a profile to be registered.

A profile should also describe how the mandatory elements of the functional standard are satisfied by the relevant part of the ISO 19100 series.

Additionally a profile may also describe aspects of the functional standard which are not included in the ISO 19100 series of standards, where a method has been described for extending the International Standard.

For example: the metadata base standard describes a method for recording and describing additional metadata elements that lie outside the scope of ISO 19115.

Considering the sets A and B as illustrated in Figure 1, where A represents an ISO 19100 series base standard and B represents a profile, we can summarize that:

$\mathbf{A} \bigcap \mathbf{B}$	Must contain the mandatory requirements as laid down in the ISO 19100 series base standard.
$\mathbf{B} - (\mathbf{A} \bigcap \mathbf{B})$	Represents those requirements that are additional to the base standard, and must be described in the profile document.
$\mathbf{A} - (\mathbf{A} \bigcap \mathbf{B})$	Represents those optional elements in the ISO 19100 series that are not required by the profile.

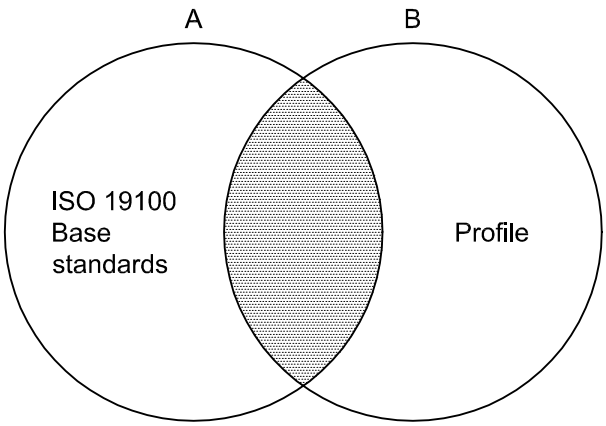

Figure 1 — ISO 19100 series base standards and profile overlap

6.2 Harmonization

6.2.1 General

In addition to describing the mapping between an implementation and the ISO 19100 series base standards, profiles can also be used as a starting point for harmonization between functional standards. By describing existing functional standards in terms of a “neutral” format, i.e. in the ISO 19100 series standard, areas of commonality between the standards can be identified, whereas areas where no overlap occurs can also be seen.

A number of studies have been carried out in the past, identifying candidate areas for harmonization between functional standards. The lessons learnt from these studies have been useful in identifying concepts that are applicable in the ISO 19100 series arena when using the “profiling” concept.

In 1995, a joint IHO-DGIWG harmonization working party was formed, focussing on the harmonization of object catalogues, data models, metadata and terminology. The output of this work was published in September 1997 as version 2 of the “Interface Control Document” (ICD). This document describes the harmonization elements on the basis of which the two standards, DIGEST and S-57, are being amended so as to achieve full harmonization.

The approach used to align the object catalogue from S-57 and feature and attribute coding catalogue (FACC) from DIGEST has been to effectively expand FACC to include the definition required by S-57. This expansion now means that the S-57 object catalogue could be considered to be a profile of the larger DIGEST FACC.

As the two standards share common catalogue definitions, which are captured in a single document, this increases the degree of harmony between the two standards in a number of ways.

— Both standards are using common feature and attribute definitions.

— A single catalogue is maintained rather than two. Future editions of the catalogue should continue to promote the harmony between the two standards, as changes will be scrutinised by a single editing committee rather than two separate organizations.

This is a simple example illustrating how a single aspect of a standard can be developed as a profile of an entirely separate standard.

One of the functional standards under consideration, DIGEST, itself illustrates the concept of profiles within its own structure. DIGEST Part 2 describes the generic elements of the DIGEST standards. It describes, in general terms, the DIGEST spatial schema, metadata requirements and quality measures. Included as Annexes to Part 2, are a number of “encapsulations”. These focus the general requirements outlined in the main body of Part 2.

EXAMPLE Annex C describes the requirements for vector data held in Vector Relational Format (VRF). This annex does not include any new concepts not discussed in the main body of DIGEST Part 2. Rather it reduces the choice available, by focussing

in on the specific requirements of vector data as opposed to gridded data. Thus Annex C is effectively a profile of the generic DIGEST requirements.

By developing the functional standards as profiles of the ISO 19100 series base standards, the respective user communities are required to review their functional standards in terms of the neutral architecture and terminology in the International Standards. The very process of profiling should clarify and sharpen up specialist definitions used within a functional standard.

As discussed previously, every in the ISO 19100 series profile must meet the mandatory requirements as laid down by the ISO 19100 series base standards, but additional common elements may be identified between the functional standards by the comparison of their profiles.

6.2.2 Applicability of ISO 19100 standard to identified functional standards

Figure 2 illustrates how the scope of three profiles can be compared to identify areas of possible harmonization. The darkest shaded area represents those elements of the profiles common to all three functional standards, lighter shaded areas indicate elements common to two functional standards, whilst unshaded areas indicate unique elements specific to each functional standard.

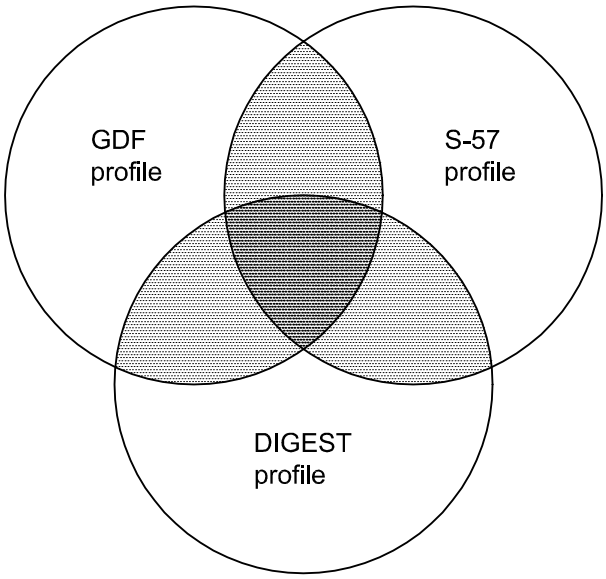

Figure 2 — Role of profiles in the harmonization of functional standards

It is useful to consider the whole range of applicable ISO 19100 series base standards when comparing two or more functional standards. Two functional standards that share both a common spatial schema and a common feature catalogue will be more in harmony than if they shared only one or the other. For the functional standards under consideration, Table 1 has been constructed to identify the level of applicability of each of the twenty ISO 19100 series base standards.

Table 1 — Applicability of standard in the ISO 19100 series to identified functional standards

Standard in ISO 19100 series	Applicability to functional standards
ISO 19101:—, *Reference model*	Referenced in the development of profiles.
ISO 19102:—, *Overview*	Used to navigate through the 19100 family of standards.
ISO 19103:—, *Conceptual schema language*	Referenced in use of 19100 schemas.
ISO 19104:—-, *Terminology*	Functional standards defined as profiles of ISO 19100 will be required to conform to ISO 19104 Terminology. Mappings of the terminology of functional standards to ISO 19104 terminology will be required until functional standard terminology is completely harmonized with ISO 19100.
ISO 19105:2000, *Conformance and testing*	Functional standards defined as profiles of ISO 19100 will have conformance causes conforming to Part 5, which specify the conformance and testing requirements of each part of ISO 19100 used in the profile.
ISO 19106:—, *Profiles*	Used by the functional standards communities in order to develop profiles.
ISO 19107:—, *Spatial schema*	The development of common modules in the base standard would increase harmonization by providing a set of common spatial sub-schemas, which could be used in the profiles of multiple functional standards. Spatial operators have been identified as of future interest to DIGEST and GDF. For GDF spatial operators will also influence the data models.
ISO 19108:—, *Temporal schema*	DIGEST treats time as an attribute, but both S-57 and GDF require the modelling of the time domain.
ISO 19109:—, *Rules for application schema*	Describes the application schema for a product. Need to ensure that the standard can support the application schemas required by the functional standard communities.
ISO 19110:—, *Feature cataloguing methodology*	A catalogue based upon all three functional standards could provide an International Core Catalogue, and would be required to allow data to be freely exchanged between the three functional standard communities.
ISO 19111:—, *Spatial referencing by coordinates*	The development of common modules in the base standard would increase harmonization by providing a set of spatial referencing systems, which could be used directly in the profiles of functional standards.
ISO 19112:—, *Spatial referencing by geographic identifiers*	Not applicable to DIGEST, but of particular interest to the GDF community.
ISO 19113:—, *Quality principles*	The development of common modules in the base standard would increase harmonization by providing a set of quality measures, which could be used in the profiles of functional standards.
ISO 19114:—, *Quality evaluation procedures*	Should support the range of evaluation measures in use in the functional standards communities.
ISO 19115:—, *Metadata*	The development of common modules in the base standard would increase harmonization by providing a set of metadata entities that could be used in the profiles of functional standards.
ISO 19116:—, *Positioning services*	Should support the technologies currently in use within the functional standards communities, particularly GDF.
ISO 19117:—, *Portrayal*	Of immediate interest to S-57, of possible future interest to DIGEST, portrayal remains an open issue in GDF community.
ISO 19118:—, *Encoding*	Appears to be a good match in the S-57/DIGEST/GDF character coding.
ISO 19119:—, *Services*	Active working group in DIGEST S-57 updating/distribution service GDF updating/distribution service.

6.3 Harmonization of functional standards

6.3.1 Granularity of ISO 19100 base standards

Some of the ISO 19100 series base standards describe a method that must be followed, whilst others provide a choice of defined elements from which the developer is required to choose elements appropriate to a particular application. This results in a range of granularity levels within the ISO 19100 series base standards.

This can mean that two ISO 19100 series-compliant datasets may not be fully interchangeable. The harmonization process of the functional standards seeks to avoid such an occurrence. One way of increasing the harmony between functional standards is to improve the level of granularity of the ISO 19100 series standards by identifying larger groupings of components (known as “modules”) from the various base standards, from which the developer can choose to build his profiles.

These modules can be considered to be pre-packaged building blocks from which the developer can quickly develop profiles, rather than having to choose from the detailed options available, or having to define new elements following a prescribed method. By defining such modules, the profiles for each of the three functional standards can be readily built from common components, thus ensuring harmony.

Modules can be considered to be pieces in a jigsaw puzzle. A number of candidate modules across the range of the ISO 19100 series standards can be identified.

EXAMPLE Within the spatial schema standard modules could be developed for Raster data, imagery data and vector data (at various topological levels). Quality Evaluation Procedures could develop modules describing different mechanisms for determining consistency and accuracy within a digital data set. Similarly Metadata could describe sets of metadata reporting entities to record extent, dataset identification and lineage. All of these modules should meet the requirements of the appropriate ISO 19100 series base standard.

The candidate modules identified here are by no means exhaustive, but are intended to give an indication of the ways in which module definitions could be made from the ISO 19100 series base standards.

Figure 3 illustrates how a profile can be readily developed from a set of predefined modules, by simply picking and choosing from the available jigsaw pieces.

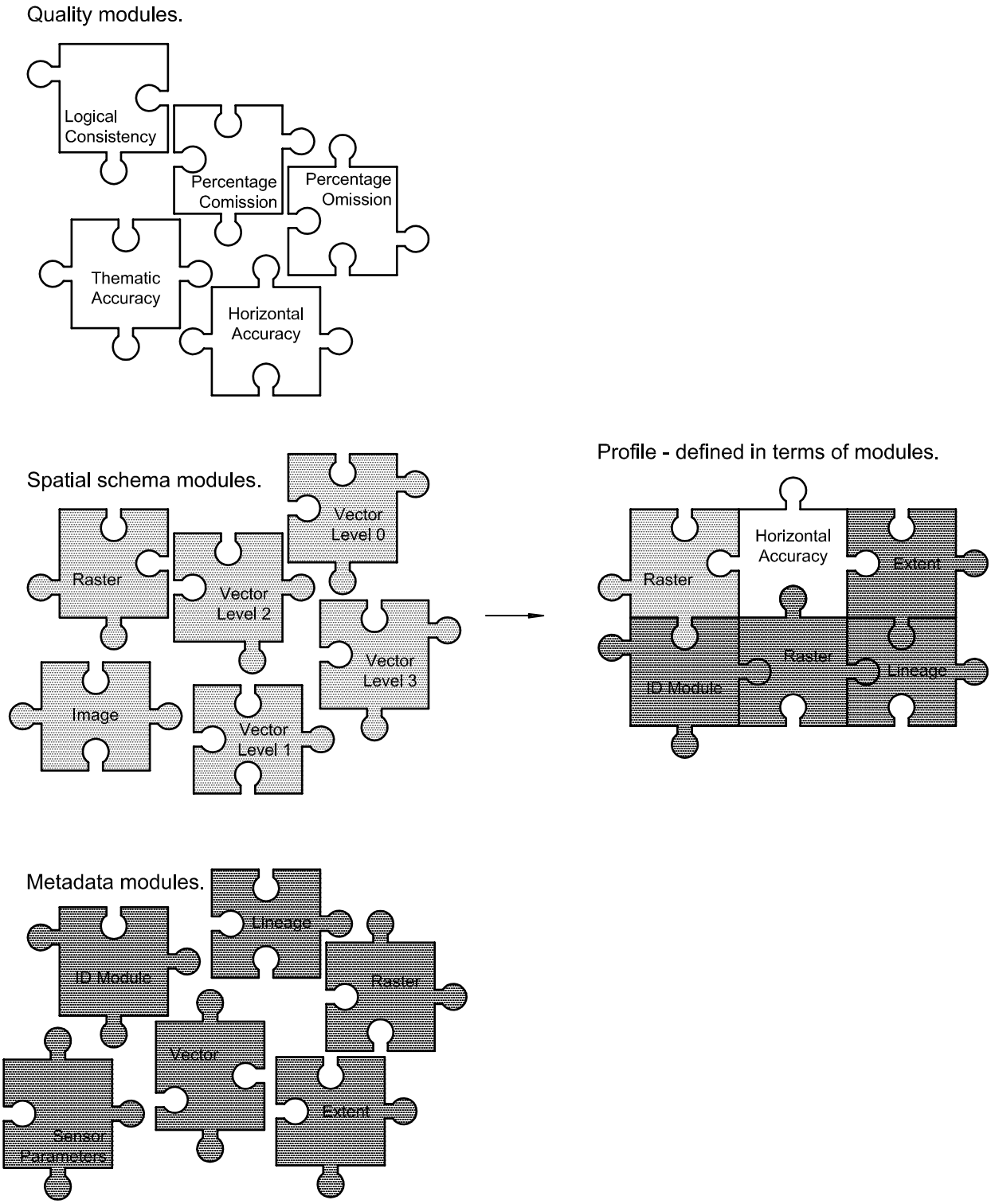

Figure 3 — Example of profile building from ISO 19100 series modules

By having a common set of modules available for the profile developer to choose from, different profiles of standards are more likely to share common components, such as spatial schema or quality evaluation methods. Two profiles

sharing such common modules will be more harmonized than profiles where the developer had to work directly from the ISO 19100 series base standard alone.

Common modules promote harmonization between functional standards in a number of ways:

— common terminology and semantics;

— common schema (as defined in a module);

— common entities (as defined in a module).

Profiles developed using such a modular concept should be easier to read and understand, as the mapping required from functional standard to the ISO base standard is at a higher level of granularity. It is much simpler to list the component modules required in a profile, rather than having to list individual components.

A functional standard addressing the requirements of a specialized community may have specific elements that cannot be readily profiled using available modules. In this situation the profiler can still use the base level element (granule) from the ISO 19100 series base standard.

6.3.2 Identification of candidate ISO 19100 modules

Consideration of the three functional standards has identified a number of areas in the ISO 19100 series base standards, where either the development of modules would be beneficial, and/or where specific input from the functional standard communities is required. These requirements have been documented in the short annexes attached to this Technical Report.

The appendices have a common format:

— a brief review of the requirements of the functional standards;

— a summary of actions identified to meet these requirements;

— a summary of cross standard dependencies, if any.

Currently 13 of the 20 ISO 19100 series of standards have been identified as of interest to the functional standards communities. Some of these standards have been identified as candidates for module development, others have been identified as arenas where the functional standards should be influencing the development of the base standard, by providing feedback or by the provision of guidelines to the project team:

— Annex A: ISO 19104, *Geographic information — Terminology*

— Annex B: ISO 19106, *Geographic information — Profiles*

— Annex C: ISO 19107, *Geographic information — Spatial schema*

— Annex D: ISO 19108, *Geographic information — Temporal schema*

— Annex E: ISO 19109, *Geographic information — Rules for application schema*

— Annex F: ISO 19110, *Geographic information — Feature cataloguing methodology*

— Annex G: ISO 19111, *Geographic information — Spatial referencing by coordinates*

— Annex H: ISO 19112, *Geographic information — Spatial referencing by geographic identifiers*

— Annex I: ISO 19113, *Geographic information — Quality principles*

— Annex J: ISO 19114, *Geographic information — Quality evaluation procedures*

— Annex K: ISO 19115, *Geographic information — Metadata*

— Annex L: ISO 19116, *Geographic information — Positioning services*

— Annex M: ISO 19117, *Geographic information — Portrayal*

— Annex N: ISO 19118, *Geographic information — Encoding*

— Annex O: ISO 19119, *Geographic information — Services*

Annex A
(informative)

ISO 19104, *Geographic information — Terminology*

A.1 Summary of functional standards characteristics

Each of the identified functional standards defines and uses its own particular terminology. The functional standards depend upon a consistent use of this terminology.

ISO 19104, *Geographic information — Terminology*, defines the terminology for the ISO 19100 series standards. In order for profiles of the functional standards to be developed, a cross-reference of 19100 terminology and functional standards terminology will be required.

A.2 Key issues to be addressed

The functional standards communities to submit their terminology definitions to the ISO 19104 project team to allow a terminology cross-comparison table to be created.

Annex B
(informative)

ISO 19106, *Geographic information — Profiles*

B.1 Summary of functional standards characteristics

ISO 19106, *Geographic information — Profiles*, describes the method whereby functional standards can become registered as profiles.

B.2 Key issues to be addressed

a) Guidelines on how to build an ISO 19100 series profile.

   Specific guidance is required on how an ISO 19100 series profile is to be developed from the ISO base standards and other registered ISO 19100 series profiles.

b) Guidelines on how to layout a profile.

   The base standard is required to provide some guidelines on how to layout a profile, with the objective that ISO 19100 series profiles should have some common layouts so that every separate profile has a common structure.

c) Profiling data dictionaries.

   Additional guidance is required from ISO on how data dictionaries, such as FACC and lists of ellipsoids, datums, projections and grids, can be registered as such in the ISO 19100 series. There is a need to check that the profiling mechanism will allow profiles to be registered as a partial solution to the requirements of the ISO base standard.

d) Product Specifications.

   Guidance is required on the development of product specifications, as profiles of the ISO 19100 series.

Annex C
(informative)

ISO 19107, *Geographic information — Spatial schema*

C.1 Summary of functional standards characteristics

C.1.1 DIGEST

DIGEST uses a variety of spatial schemas. These are summarized in Table C.1. For DIGEST to be fully harmonized as a series of profiles of the ISO 19100 series, a number of topographic/geometric relationships and entities may need to be supported by ISO 19107. A detailed list of the required relationships and entities is not provided in this report. These entities should be grouped into pre-defined schema modules for direct use by profile developers. Some work has been carried out within the ISO 19100 series arena to exercise the spatial schema developed in ISO 19107 by describing the DIGEST vector Planar Graph with Faces in terms of the base standard. An example of DIGEST described in the ISO 19107 Planar Graph with Faces Spatial in EXPRESS-G given in Figure C.1. This diagram does not imply any specific spatial schema requirements for ISO 19107. It is intended to show how one DIGEST schema might be described using the guidance found in ISO 19107.

Table C.1 — Table summarizing spatial modelling characteristics across the three functional standards

Spatial Model	DIGEST	S-57	GDF
Vector Level 0 – “Spaghetti”	YES	YES	
Vector Level 1 – “Chain Node”	YES	YES	
Vector Level 2 –“Planar Graph”	YES	YES	YES
Vector Level 3 – “Planar Graph with Faces”	YES A/B/C	YES	YES
Raster/Image	YES	Future - can potentially mix raster and vector	
Matrix and other point grids	YES	Future - can potentially mix matrix and vector	

DIGEST utilizes queries based upon spatial relationships between features at both a data warehouse and at an application level. ISO 19107 may need to support these relationships. A complete list of the DIGEST relationships is not provided in this report but include “stacked on” and “connected to”.

C.1.2 GDF

The final definition of the spatial model to be used in the ISO version of GDF is still under discussion.

C.1.3 S-57

In the future it is possible that S-57 will support the mixing of matrix and vector data, and of raster and vector data in a single coverage (i.e. matrix or raster data could be a spatial primitive in a vector coverage).

C.2 Key issues to be addressed

ISO 19107, *Geographic information — Spatial schema*, project team should develop modules to support a number of vector topographical and spatial relationships.

— Vector data modelled as “Spaghetti”, “Chain-Node”, “Planar Graph”, “Planar Graph with Face”, levels of topology.

— Modules supporting application-level topology, by allowing vector entities to display relationships with other vector entities (“Stacked On”, “Stacked Under”, “Conjunction”, “Disconjunction”, where the last two indicate presence or absence of flow at junctions).

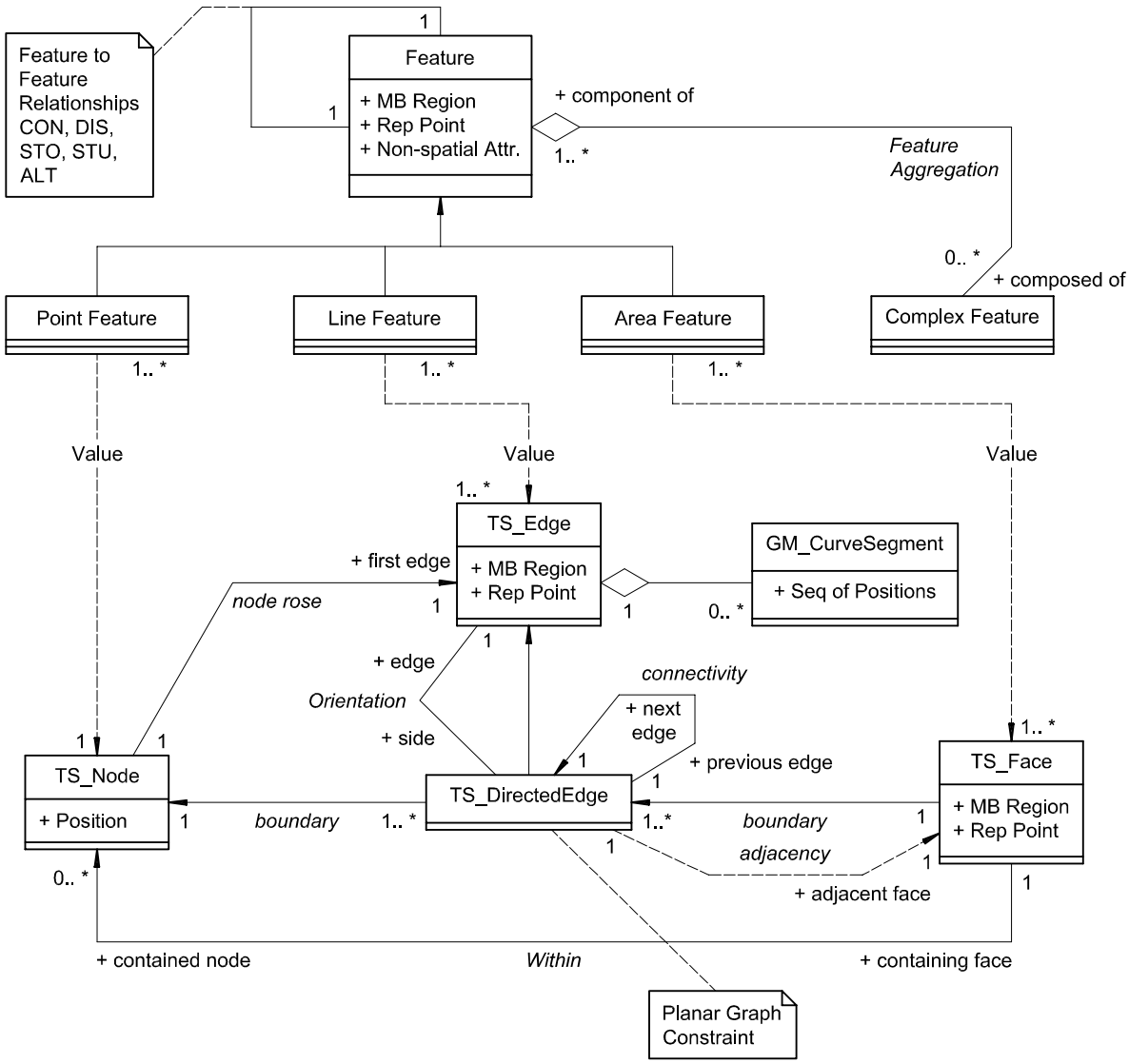

Figure C.1 — Example: DIGEST described in the ISO 19107 Planar Graph with Faces Spatial in UML

— Modules should support vector data held in a tiled format.

— DIGEST uses a model called Winged Edge Topology to describe faces, rings and cross tile topological relationships.

— Relationships with other existing ISO and OGC work packages. i.e. SQL-MM and OGIS.

A number of raster/image/matrix requirements must be supported by the ISO 19107 spatial schema modules.

— Raster sub-blocks

— Direct and indirect raster

— Non-colour/colour maps

Other issues to be addressed by the ISO 19107 Spatial schema modules.

— S-57 may in the future support the mixing of matrix and vector data. ISO 19107 should support the mixing of these types of data.

C.3 Response from project team

Existing standards have formed an input to the work item. The feature to feature spatial relationships can be supported in the General Feature Model by using the relationship entity. The standard will be extended to describe this functionality.

Annex D
(informative)

ISO 19108, *Geographic information — Temporal schema*

D.1 Summary of functional standards characteristics

DIGEST treats time as an attribute. S-57 and GDF model the time domain. S-57 in particular models time-varying objects (such as tides). For all three functional standards to be fully harmonized with the ISO 19100 series, ISO 19108 may have to support both methods of dealing with time. Both S-57 and GDF utilize temporal information to perform incremental updates of in-service data products.

D.2 Key issues to be addressed

Modules required to ensure that time is available as an attribute and that time modelled as a dimension will support functions such as tides.

Specific issues to be considered by the ISO 19108 team:

— linear time;

— cyclical time (tides, seasons);

— indirect temporal measurement;

— considering time as a dimension suggests the existence of higher levels of topology, with all the overheads that this implies.

Annex E
(informative)

ISO 19109, *Geographic information — Rules for application schema*

E.1 Summary of functional standards characteristics

DIGEST application schemas can be extracted from a series of products defined by the standard. S-57 and GDF do not contain explicit application schemas as defined by ISO 19109, but at least one can be inferred for each standard. This report does not address any specific characteristics of the functional standards application schemas.

E.2 Key issues to be addressed

The rules for application schema standard must be able to describe and support the various products of the functional standards communities.

Rules for application schema should provide an input into the products part of the work item Profiles, which is the basis for the development of ISO 19106, *Geographic information — Profiles*.

Annex F
(informative)

ISO 19110, *Geographic information — Feature cataloguing methodology*

F.1 Summary of functional standards characteristics

ISO 19110, *Geographic information — Feature cataloguing methodology*, standardizes a singular method of cataloguing features. Since a singular method was deemed necessary for this standard, it is impossible for the functional standards to contribute requirements for the general methodology described in the standard unless they all currently used the same methodology. This report does not address the specific cataloguing methods used by the functional standards, rather a few unique characteristics of the DIGEST and S-57 catalogues have been identified. Defining DIGEST or S-57 as a profile of ISO 19100 series of standards may be simplified if the ISO 19110 contains similar characteristics.

F.2 Key issues to be addressed

The ISO 19110 method must be able to cope with, and should provide guidance on how catalogue developers should cope with

— repeating attributes (e.g. a radio beacon could have a list of frequencies associated as attributes),

— attributes with attributes (e.g. Navigation Buoys have a series of colours which indicate navigation-related information; therefore the combination of colours of the buoys and the associated sequence in which they are displayed is important),

— catalogue granularity (when is an attribute a feature and vice versa), and

— support for multi-language definitions, within a single catalogue, of feature, attribute, function and relationships.

F.3 Response from project team

The cataloguing team felt that these issues can be supported within the current base standard. Examples will be developed to illustrate these issues in the informative appendices.

Comments were made that the requirement for rich attributes (attributes with attributes) might have a knock-on effect into the conceptual schema language. The language chosen for the ISO/TC 211 standards must be able to cope with lists, or arrays as well as complex data types.

Additional guidance is required to help the profiler develop catalogues with various levels of granularity. The use of the relationship entities (such as generalization and aggregation) allows the developer to define multiple levels of granularity within a single catalogue.

Annex G
(informative)

ISO 19111, *Geographic information — Spatial referencing by coordinates*

G.1 Summary of functional standards characteristics

DIGEST, S-57, and GDF all contain parameters and attributes specific to geospatial referencing. For all three functional standards to be fully defined as profiles, ISO 19111, *Geographic information — Spatial referencing by coordinates*, may have to support all of these parameters and attributes. This report does not address the specifics of the spatial referencing parameters and attributes of any of the functional standards. Particularly, the report does not identify whether there are any inconsistencies among the parameters provided for by each functional standard. A few general categories of parameters that may need to be supported have been identified.

G.2 Key issues to be addressed

ISO 19111, *Geographic information — Spatial referencing by coordinates*, must be able to address these issues.

— Hydrographic sounding datums.

— Satellite orbital parameters.

NOTE These can be disregarded if within the scope of the Positioning services work item.

— Maps with a non-geodetic datum (e.g. oil exploration or no datum known).

— Deliberately degraded mapping (commercial or military).

— Are lists of ellipsoids, datums, grid systems and projections to be included in the standard? If not guidelines are required to aid the generation of profiles for this purpose.

Annex H
(informative)

ISO 19112, *Geographic information — Spatial referencing by geographic identifiers*

None of the functional standards currently contains characteristics specific to spatial referencing by geographic identifiers, although the GDF community is known to be working on that topic. This report does not address any aspect of that work.

Annex I
(informative)

ISO 19113, *Geographic information — Quality principles*

I.1 Summary of functional standards characteristics

All three functional standards contain elements for spatial quality that may need to be supported by ISO 19113. The S-57 “Zone of Confidence” quality element has been identified as one unique characteristic that should be investigated further.

I.2 Key issues to be addressed

S-57 Zone of Confidence quality requirement.

I.3 Response from project team

This issue should be addressed within ISO 19114, *Geographic information — Quality evaluation procedures.* ISO 19113*, Geographic information — Quality principles*, deals with the principles of measuring quality, and as such the standard is generic enough to cover all types of quality measurement.

Annex J
(informative)

ISO 19114, *Geographic information — Quality evaluation procedures*

J.1 Summary of functional standards characteristics

All three functional standards contain elements for spatial quality that may need to be supported by ISO 19114. The S-57 “Zone of Confidence” quality element has been identified as one element that has unique quality evaluation characteristics that should be investigated further.

J.2 Key issues to be addressed

S-57 Zone of Confidence quality requirement.

There are a number of different types of quality measurement. One of the more unusual types of measures is the S-57 Zone of Confidence quality requirement. This measures the confidence that, for a given area, the Hydrographic depth of water will exceed a stated figure (enabling shipping of an appropriate draught to pass with safety).

The project team should give some consideration to defining a set of commonly used quality evaluation procedures as annexes to the standard. These could be used as modules by profilers.

Annex K
(informative)

ISO 19115, *Geographic information — Metadata*

K.1 Summary of functional standards characteristics

All three functional standards contain metadata elements. These elements may need to be supported, either directly or indirectly, by ISO 19115. The functional standards community should advise the metadata development team on increasing the granularity of the ISO 19115 metadata elements in order to form a set of metadata modules which can be used directly by profile developers.

K.2 Key issues to be addressed

ISO 19115, *Geographic information — Metadata*, must be able to deal with

— inheritance of metadata,

— overlapping metadata sets,

— specialized metadata requirements, and

— identify candidate modules for inclusion in ISO 19115, *Geographic information — Metadata*, in order to ease the task of profiling the functional standards.

K.3 Response from project team

The Metadata standard has been restructured in an effort to make the base standard modular.

Annex L
(informative)

ISO 19116, *Geographic information — Positioning services*

L.1 Summary of functional standards characteristics

Positioning services and technology are known to be in use within the functional standards community. This report does not identify any specific characteristics of those services and technology.

L.2 Key issues to be addressed

ISO 19116, *Geographic information — Positioning services*, must be able to address the following issue:

— the recording of satellite orbital parameters.

NOTE This issue has also been raised with the ISO 19111, *Geographic information — Spatial referencing by coordinates*, project team. The important point is that the issue is addressed in one of these arenas.

L.3 Response from project team

An element has been provided in the positioning services base standard, that can be used to describe the operating parameters of the positioning technology. This should be used to describe satellite orbital parameters.

Annex M
(informative)

ISO 19117, *Geographic information — Portrayal*

M.1 Summary of functional standards characteristics

DIGEST, GDF and S-57 all support various portrayal mechanisms.

The current DIGEST portrayal mechanism is under study.

The portrayal mechanisms to be implemented in the GDF standard are still under discussion within the ISO/TC 204 forum.

S52, published by the International Hydrographic Organization (IHO) describes the characteristics of ECDIS (Electronic Chart Display Information System). Annex 1 contains a glossary of ECDIS terminology, Annex 2 describes the colours and symbols to be used for presentation and Annex 3 describes the process to be used for updating ECDIS data. Annex 2 is supplemented by a software presentation library which provides a feature driven, rule based standardized portrayal mechanism.

Portrayal issues within S-57 are complex as they deal directly with the safety of shipping and navigation. S-57 may contain portrayal characteristics that should be supported by ISO 19117, *Geographic information — Portrayal*.

M.2 Key issues to be addressed

— ISO 19117, *Geographic information — Portrayal*, should have links to existing multimedia standards such as MPEG and MPEH, in order to avoid duplication of effort.

— Feature driven, rule based standardized portrayal mechanisms are required by some applications.

M.3 Response from project team

The portrayal base standard has been written to be format independent. Profilers may make use of existing portrayal standards, and compression techniques when developing portrayal catalogues.

The Portrayal standard describes a method of defining feature/attribute-driven rules for portrayal.

Annex N
(informative)

ISO 19118, *Geographic information — Encoding*

N.1 Summary of functional standards characteristics

The three functional standards, as a group, employ multiple encoding methods. DIGEST, in particular, employs more than one encoding method. This report does not identify whether there are any encoding methods in common among all three functional standards. This report does not address whether any, one, or all of the encoding methods employed by the functional standards need to be supported by the ISO 19100 series.

N.2 Issues to be addressed

All of the functional standards currently identify variations of ISO/IEC 8211, ISO/IEC 8824, relational tables (VRF), BIIF, other standardized raster formats, matrix/grid formats. These should be addressed by the draft standard.

The common repertoires of primitive encoding elements must select, from a broad array of ISO standards (some of which are obsolete), a sub-set to be used in the profiled standard.

DIGEST currently includes multiple encapsulations to address different purposes. The DGIWG is interested in reviewing encoding schemes displaying new capacities and functionality to meet future requirements.

Annex O
(informative)

ISO 19119, *Geographic information — Services*

O.1 Summary of functional standards characteristics

DIGEST, GDF and S-57 define services within their functional standards.

DIGEST services are APIs for DIGEST software tools. DIGEST and S-57 support updates of datasets. DIGEST currently uses a differential file replacement update, whereas S-57 supports a transaction oriented element update.

Update mechanisms have been identified as of interest to the GDF community. Detailed update mechanisms are currently under discussion in the ISO/TC 204 forum. ISO/TC 204 is working to develop common API's and physical storage formats for road navigation applications.

O.2 Issues to be addressed

A number of issues need to be considered within the ISO 19119, *Geographic information — Services*, project team.

— Update mechanisms.
  — Update at dataset level, by differential file replacement.
  — Incremental Updates — Mechanism identified to allow the updating of datasets at a transaction level, where individual features, attributes, functions, and relationships could be identified and updated.
— Interfacing with other layers of ISO/OSI interchange standards e.g. encryption, error protection, addressing, routing. The key issue is that mechanisms addressed in other arenas should not be reinvented within the ISO 19100 series.

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